NAVY (WATER-TUBE BOILERS)

REPORT

ON

FURTHER TRIALS

OF

H.M.S. "HYACINTH" AND H.M.S. "MINERVA."

(WITH DIAGRAMS.)

Presented to both Houses of Parliament by Command of His Majesty.

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Report on Further Trials of H.M.S. "Hyacinth" and H.M.S. "Minerva."

At the conclusion of the trials of H.M. Ships "Hyacinth" and "Minerva," to Gibraltar and back, made 6th–20th July 1901, under the supervision of the Boiler Committee, it was reported that on the run out, at 7,000 I.H.P., a considerable difference of speed existed between the two ships; while on the run home, at full power, although the "Hyacinth" developed on an average 1,000 I.H.P. more than the "Minerva," yet her speed was slightly less. An investigation into the causes of these bad performances on the part of the "Hyacinth" was therefore ordered.

The performances of the two ships during the runs, as inserted in the engine-room registers, were carefully examined, and the curves of speed and indicated horse power shown in Diagram I. were found to approximately represent the performances of the two ships during the runs. The portions of these curves between 16 and 20 knots for normal draught of water are shown superimposed in Diagram II., which also shows a curve of difference of indicated horse power between these limits.

From the statements of the draughts of water of the two ships when leaving Gibraltar, and on arrival at Spithead, the "Hyacinth" appears to have been about 100 tons heavier than the "Minerva." This would involve a somewhat greater indicated horse power for a given speed, but the difference is not considerable.

As both ships were docked immediately before starting for Gibraltar, no part of the difference of indicated horse power required to obtain the same speed can be due to different degrees of foulness of bottom, and it can only be due to—

(1.) Differences in shape of hull.
(2.) „ „ engine friction.
(3.) „ „ efficiency of propellers.

From model experiments it is known that, so far as the forms of the ships are concerned, at equal draughts and displacements, the "Hyacinth" should require at the outside 300 I.H.P. more than the "Minerva" at 20 knots, about 100 I.H.P. more at 18 knots, and practically the same indicated horse power at 16 knots. The difference in dimensions and form cannot, therefore, account, under conditions of practice, for any sensible difference in speed with equal engine power. This difference in indicated horse power for equal speeds, due to the shape of hull, is shown by the dotted curve in Diagram II., the remaining power between the dotted and full curves is due to the combined effects of the differences in engine friction and of differences due to the efficiency of the propellers.

From an examination of the shaft friction tests that had been made from time to time for vessels of this class, no reason was found to suspect that any excessive engine friction existed in the "Hyacinth" as compared with the "Minerva." These tests, however, deal only with the friction of the propeller shaft itself, and are no guide to the friction of the engines. On this latter point, the only information for the "Hyacinth" was that, on one occasion, going dead slow, she developed 61 I.H.P. at 15·7 revolutions, which shows that the engine friction could not be excessive. As there was no corresponding figure for the "Minerva," it was decided to make actual trials in both ships by removing the propellers and running the engines at revolutions ranging from the lowest possible up to those corresponding to the full power of the ships. Indicator diagrams were taken at each speed, special springs being used to enable an accurate measurement of indicated horse power to be made. The results of these trials, which were made at Devonport in February 1902, are shown in Table I. and Diagram III.; they are practically identical for the two ships, and prove that the engine friction amounted in each case to about 5 per cent. of the power when the engines were developing their full power. The engine friction could, not, therefore, account for any part of the comparative loss of power in the "Hyacinth," and that part of it not due to

difference in form was, therefore, wholly due to the relative inefficiency of her propellers.

As a first step to improve the performance of the "Hyacinth," it was determined to slightly cut down the diameter of the propeller blades and modify the pitch. When this was completed and the propeller replaced, the ships ran together on the deep-sea course off Plymouth at speeds of 16 and 18 knots, and at specified full natural draught power—four runs being made at each speed. Both vessels were at the draught of 19 ft. 6 ins. forward, 22 ft. 6 ins. aft.

The runs were made on the 21st-25th April 1902, and the results were as follows:—

"Hyacinth."			"Minerva."		
Speed.	Revs.	I.H.P.	Speed.	Revs.	I.H.P.
Knots.	Per min.		Knots.	Per min.	
15·60	135	5,006	15·96	112	4,889
17·67	157	8,062	17·67	126	7,323
18·60	172	10,166	18·28	131	8,394

The comparatively low speeds obtained by both ships on these trials were due to weather conditions and slight foulness of bottom. The speeds and powers are shown plotted in Diagram IV., Fig. 2; they show that the "Minerva's" propeller was more efficient than the "Hyacinth's," as altered; but owing to absence of reliable trial data for the original propeller of the "Hyacinth," it could not be said with certainty that any material gain had been realised in the "Hyacinth" by altering her propellers. Subsequent trials on the Chesil Beach course, with the propellers restored to their original dimensions and shape, proved that some gain had been effected by the alteration.

While these trials were in progress, the question of fitting propellers of new dimensions to the "Hyacinth" was under consideration, and after a careful investigation and comparison of all the propellers of recent fast ships, it was anticipated that better results could be obtained in the "Hyacinth" by the adoption of propeller blades of different dimensions and shape to those hitherto adopted in His Majesty's Service, which from the experience of the "Hyacinth" and other quick-running vessels, do not perform so well at high revolutions as at the correspondingly lower revolutions of the "Minerva" and earlier ships.

Five propellers of different dimensions were then prepared. These are called, for the purposes of this report, A, B, C, D, and E. Of these A was the propeller with which the ship ran the trials for the Boiler Committee.

The following series of trials were carried out by the two ships over the measured distance on Chesil Beach. Six runs were made at each speed. The ships ran together in each trial and were both at a draught of forward 19 ft. 6 ins., aft 22 ft. 6 ins. throughout. The results of these trials were as follows:—

"Hyacinth," with Propeller A.			"Minerva."		
Speed.	Revs.	I.H.P.	Speed.	Revs.	I.H.P.
Knots.	Per min.		Knots.	Per min.	
16·19	138	5,105	15·94	110	4,408
18·08	160	8,045	17·94	126	6,885
18·70	175	10,377	18·65	132	8,246

The weather conditions for this trial were satisfactory, and the results obtained are shown plotted in Diagram IV., Fig. 1. These bring out very

distinctly the relative inefficiency of the propellers as originally fitted in the "Hyacinth."

"Hyacinth," with Propeller B.			"Minerva."		
Speed.	Revs.	I.H.P.	Speed.	Revs.	I.H.P.
Knots.	Per min.		Knots.	Per min.	
15·88	145	4,924	16·01	110	4,590
17·99	166	7,583	17·88	126	7,142
19·40	181	10,309	18·55	133	8,449

The weather conditions for this trial were satisfactory. The results obtained are shown plotted in Diagram V., Fig. 1. Compared with the trial made on the deep-sea course the "Minerva" made better speeds than on that occasion, while the "Hyacinth" made much better speeds, the net gain for the "Hyacinth" being about 0·4 knot at 10,000 I.H.P.

"Hyacinth," with Propeller C.			"Minerva."		
Speed.	Revs.	I.H.P.	Speed.	Revs.	I.H.P.
Knots.	Per min.		Knots.	Per min.	
16·49	152	5,507	16·24	112	4,634
18·22	171	8,079	18·17	127	7,149
19·44	185	10,510	18·59	132	8,215

The weather conditions for this trial also were satisfactory, and the results obtained are plotted in Diagram VI., Fig. 1. This propeller also proved to be more efficient than the original propeller as cut down for speeds above 16 knots, but this gain was not quite so large as with propeller B.

"Hyacinth," with Propeller D.			"Minerva."		
Speed.	Revs.	I.H.P.	Speed.	Revs.	I.H.P.
Knots.	Per min.		Knots.	Per min.	
16·72	146	5,589	15·94	110	4,524
18·24	163	7,819	17·96	127	7,217
19·32	175	10,129	18·53	132	8,254

The weather conditions for this trial were also satisfactory, and the results obtained are shown plotted on Diagram VI., Fig. 2. An improved performance was obtained at all speeds over the last trial.

"Hyacinth," with Propeller E.			"Minerva."		
Speed.	Revs.	I.H.P.	Speed.	Revs.	I.H.P.
Knots.	Per min.		Knots.	Per min.	
16·44	140	5,200	16·03	111	4,567
18·16	160	7,756	18·12	127	7,095
19·67	175	10,613	18·59	133	8,319

The weather conditions on this trial were not altogether satisfactory. The wind was high (reaching a velocity of 23 knots during the middle run) and

the sea lumpy, but so far as the "Minerva" is concerned she repeated on this occasion her performance in trials 2 and 3 when the weather conditions were favourable.

The "Hyacinth" made a speed of 19·67 knots, which is ¼ knot in excess of any previous speed in the present series.

The results obtained during the trial are plotted in Diagram V., Fig. 2.

This trial completed the series that were run by the "Hyacinth" with modified screws, and the "Minerva" with her original screws throughout.

The best speeds that were obtained by the "Hyacinth" with the various propellers tried in this series of trials compare as follows:—

	Maximum obtained.		Speed at 8,000 I.H.P.	Speed at 10,000 I.H.P.
	Speed.	I.H.P.		
	Knots.		Knots.	Knots.
Original propellers cut down - - -	18·60	10,166	17·63	18·53
A - - - - - -	18·70	10,377	18·06	18·63
B - - - - - -	19·40	10,309	18·25	19·25
C - - - - - -	19·44	10,510	18·18	19·20
D - - - - - -	19·32	10,129	18·34	19·28
E - - - - - -	19·67	10,613	18·25	19·38

Propeller E gave the best result at top speed, although it appears slightly inferior to D for speeds below 18 knots; the former propeller was left on the ship at the conclusion of the above trials.

It will be noticed that the total speed gained by the present propellers over those originally fitted is very nearly a knot (viz., 0·97 knot), or allowing for difference in indicated horse power the gain is 0·8 knot, the equivalent in power gained being about 1,500 I.H.P.

The previous inefficiency of the propellers having been so far rectified, it was decided to repeat the long-distance trials made by the Boiler Committee with a view to obtaining more extended results.

Orders were accordingly given for both vessels to carry out the following programme, which includes three trials:—

(*a.*) A passage from Plymouth to Gibraltar at 7,000 I.H.P., to measure the coal and water consumption, the two vessels carrying out the trial in company and continuing until their coal was exhausted, with the exception of a reserve for emergencies, and a small quantity sufficient to enable them to reach port.

(*b.*) Measurement of the minimum time necessary after arrival in port to coal, make good any defects, clean boilers, and put to sea again.

(*c.*) A passage trial from Gibraltar to Portsmouth at the highest speed possible, commencing with both vessels lying at anchor at Gibraltar with cold water in their boilers. On the signal to start being given, the least time in which the vessels could get under way from these conditions to be measured, and the maximum speed they were capable of maintaining on this passage ascertained.

To carry out the first trial of the series, both vessels left Plymouth together at 10 a.m. on the 4th February; they passed Gibraltar together at 11 p.m. on the 6th February, and then steamed backwards and forwards along a set course off the S.W. coast of Spain until the specified quantity of coal remained unburnt.

The records of indicated horse power, coal and water consumption, &c. of the "Hyacinth" do not, however, commence before 10.30 a.m. on the 4th February, those of the "Minerva" starting at 10.25 a.m.

The "Hyacinth" put into Gibraltar at 2.30 a.m. on the 10th February, having been on trial 136 hours, and burnt 898·5 tons of coal, whilst the "Minerva" arrived at 2.25 a.m. on the 11th February, 160 hours after starting the trial, and in this period she consumed 989 tons of coal. The details of the results obtained are shown in Tables II., IIA., and IIB.

The difference in the amount of coal consumed by the two vessels is due to two facts:—

(1.) The actual total coal capacity of the "Minerva" is greater than that of the "Hyacinth."

(2.) The reserve bunkers of the "Hyacinth" are larger than those of the "Minerva," and these bunkers were ordered to be left untouched in both ships.

As a consequence the "Hyacinth" had 91 tons less available to burn than the "Minerva," which, together with a slightly higher economy, enabled the latter to remain at sea 24 hours longer.

The total distance steamed was 2,832·8 miles by the "Minerva" for 989 tons of coal, and 2,390 miles by the "Hyacinth" for 898·5 tons of coal.

Special care was taken to ensure the measurements of consumption of coal and water being accurate. The expenditure of coal during the trial was measured by counting the number of skids (of known capacity) used per hour. Also the coal actually in the vessels before coaling at Devonport was independently surveyed, the coal was weighed into the ship in bags, and a survey of the remains made at Gibraltar. The results obtained by the two methods of measurement were in close agreement.

The "Minerva," on leaving Plymouth, had her reserve feed-tanks full (170 tons, approximately) and the water lost was made up from these until an emergency reserve of 44 tons remained at the end of 98¼ hours, and from this time until the end of the trial the water lost was made up by the evaporators. The total water lost was 183·2 tons in 160 hours.

The "Hyacinth," on leaving Plymouth, had 140 tons of water in her reserve feed-tanks, and after using 100 tons the evaporators were started for make-up. The total water lost was 169·67 tons in 136 hours.

The revolutions and power were kept as nearly constant in each vessel as possible; the coal consumption, and water loss were also practically constant, as may be seen from the details, shown on Tables IIA. and IIB.

As regards the speeds obtained by the ships, the following table gives the results for succeeding periods of 24 hours each:—

"Hyacinth."			"Minerva."		
Speed.	Revs.	I.H.P.	Speed.	Revs.	I.H.P.
Knots.	Per min.		Knots.	Per min.	
17·5	151·2	6,967	17·3	122·1	7,060
17·6	153·8	7,115	17·7	122·2	7,036
17·5	153·7	7,095	17·5	122·0	7,025
17·8	153·6	7,041	17·8	122·8	7,010
17·6	151·5	6,917	17·9	121·9	7,034

When the ships passed Gibraltar they were within 3 miles of each other and their speeds at 7,000 I.H.P. were therefore practically identical. This bears out the speeds deduced from the daily runs which are shown in the above table.

The air pressure in the "Hyacinth" varied from *nil* to 0·20 in., whilst in the "Minerva," at the end of the trial, a maximum of 2·0 ins. was reached in order to maintain the power. This air pressure was rendered necessary by the choking of the tube ferrules, in some cases the tube being completely choked, whilst in others about three-quarters of the area was choked. There was in addition a heavy deposit of scoriæ on the tube plates at the end of the trial, the thickness diminishing towards the top of the combustion chamber.

In other respects the boilers and machinery worked satisfactorily, and no defects of any importance were developed during this run in either vessel.

In the "Minerva," after 21 hours' steaming, the port high-pressure piston-rod gland and the starboard high-pressure slide-rod gland leaked. At the latter part of the trial the starboard high-pressure piston-rod gland and the port high-pressure slide-rod gland also leaked. There were, in addition, slight leaks from the feed pipes, and the steam pipe to one fan engine was defective.

In the "Hyacinth" the gland of the port reducing-valve leaked, and at various times during the trial sixteen fusible plugs were replaced, seven new gauge glasses and two new nickel rings were fitted.

Comparing the results of this run with the similar passage made in July 1901, under the direction of the Boiler Committee, it will be seen that as regards coal consumption the "Hyacinth" is 1·5 per cent. more, and the "Minerva" 6·2 per cent. less, than on that occasion.

As regards water loss, however, the "Hyacinth" lost on this trial less than half the amount previously recorded, whilst the "Minerva" was 17·1 per cent. in excess of her previous record.

The object of the second trial of the series was to determine the least time in which the two vessels could be coaled and again made ready for sea.

Table III. gives the time of arrival and the periods after the termination of the trial at 7,000 I.H.P., when each operation was completed. The work of cleaning the boilers, &c. was commenced immediately after the first trial ended and before the vessels reached harbour, and consequently this time has been considered the basis of the various periods rather than the time of arrival at Gibraltar.

The "Minerva" completed her first trial approximately 24 hours after the "Hyacinth," and all her operations were 24 hours later than those of the "Hyacinth, but it has been assumed for the sake of comparison that both vessels arrived at the same time.

To prepare for sea, as regards engines and boilers, the "Hyacinth" took 21 hours and the "Minerva" took 45 hours.

On completion of coaling the vessels proceeded to an anchorage in the bay, and there remained until the signal to proceed at full speed to Portsmouth was made.

One boiler out of eight was in use in the "Minerva" for harbour purposes, whilst two out of eighteen were employed in the "Hyacinth," and care was taken that no steam leakage took place from the boilers in use to those not in use, nor to the main engines.

The coal taken on board at Gibraltar was, as in the case of that received at Devonport, from the same cargo, and under precisely the same conditions for both vessels. The coal was weighed into each ship, and the amount actually on board confirmed by survey.

The "Hyacinth" was completed to 1,012 tons, and the "Minerva" to 976 tons, the object of this difference being to ensure equal displacements in the two vessels on the run home, it being anticipated that the indicated horse-power of the "Hyacinth," and hence, *ceteris paribus*, the total coal used, would be in excess of that of the "Minerva" to the above extent.

The adjustments made at Gibraltar in the "Hyacinth" included the following:—

Starboard high-pressure crank-head adjusted.
One main bearing adjusted.
Main condenser, port, tested.
Piston-rod and slide-rod glands of main engines repacked.
Glands of spindles of both reducing valves repacked.
Repacked piston and slide rod glands of auxiliary engines as necessary
Renewed three leaky nickel rings in No. 6 boiler.
Renewed upper fusible plugs in sixteen boilers.
Ten economiser doors rejointed.

In the "Minerva" the following adjustments were made:—

Both high-pressure piston and slide-rod glands repacked and metallic packing of same refitted.
Starboard intermediate pressure cross-head adjusted.
Adjusted brasses of three fan engines.
Steam and exhaust pipes of one fan engine rebrazed.
Suction pipe to No. 1 auxiliary feed engine rebrazed.
Brickwork of boilers rebuilt as necessary, and burnt firebars replaced.

All these defects and adjustments were made good by the staffs of the respective ships with the exception of those in italics, for executing which the assistance of the Dockyard was required.

The water in the boilers had been gradually cooling, and at 8 a.m. on the morning of the 15th, just previous to the signal being given to start, the following temperatures were recorded :—

" Hyacinth " :—

Mean temperature of four boilers of after group (in which were situated the two auxiliary boilers) -	74·5° F.
Mean temperature of remaining twelve boilers - -	63° F.
Mean temperature of engine room - - -	86·5° F.

" Minerva " :

No. 6 boiler (next to No. 8, which was in use for auxiliary purposes) - - - Mean	115° F.
Mean of remaining six boilers - - - -	80° F.
Mean temperature of engine room - - -	79° F.

The signal to proceed to Portsmouth at full speed was made at 9 a.m. on the 15th February, and both vessels at once lit fires in the boilers not then in use, and commenced warming up engines.

The following times were noted in the " Hyacinth " during the process of raising steam and getting under way :—

9.0 a.m. Lit fires in sixteen boilers and admitted steam gradually to engines from auxiliary boilers.

9.20 a.m. Moved engines by steam by working reversing engine. Connected after group of boilers (6 in No.) to engines. Steam in boilers 120 lbs., engines 60 lbs.

9.22 a.m. Engines made a complete revolution ahead and astern and were reported ready to proceed.

9.25 a.m. Slow ahead and as necessary to leave anchorage.

9.28 a.m. Middle group of boilers (6 in No.) connected, steam at 210 lbs.

9.32 a.m. Forward group of boilers (6 in No.) connected, steam at 290 lbs.

9.45 a.m. Ship making 18½ knots.

10.0 a.m. Commenced taking records.

The corresponding times in the " Minerva " were as follows :—

9.0 a.m. Lit one wing fire in each of seven boilers, started fan engines and commenced warming through main engines from auxiliary boiler. A few minutes later lit centre fires and third fire of No. 6 (the one next to the auxiliary boiler).

9.30 a.m. Steam showed in No. 6 boiler.

9.35 a.m. Third furnace in each of the remaining six boilers lit.

9.45 a.m. Steam showed in remaining six boilers.

9.50 a.m. Steam at 75 lbs. in No. 6 boiler. Low-pressure cylinders warm to the hand.

9.55 a.m. Links worked by reversing engine.

9.56 a.m. Connected No. 6 boiler to engines with 108 lbs. of steam.

10.0 a.m. Low-pressure cylinders warm enough to allow engines to be moved.

10.3 a.m. Slow ahead, and as required to leave anchorage. Nos. 6 and 8 boilers only in use.

10.12 a.m. All boilers connected.

10.15 a.m. Working up to full power, mean revolutions, 123 per minute. Steam in boilers, 150 lbs.

10.20 a.m. Engines making 130 revolutions per minute, and developing 8,321 I.H.P.

The " Hyacinth " thus left the anchorage at 9.26 a.m., or 26 minutes after the signal, and the " Minerva " at 10.4 a.m., or 64 minutes after the signal, the " Hyacinth " having obtained a lead of 38 minutes.

Shortly after the commencement of the trial, the starboard after low-pressure slide-rod guide in the " Hyacinth " warmed up, and the engines were eased for seven minutes to cool it.

At 3.59 p.m., or about 6½ hours after leaving the anchorage, the port intermediate pressure crank-head bearing in the "Hyacinth" was found to be warm. This was quickly cooled down and any tendency to warm up again was prevented by keeping a small hose running on this bearing, and the bearing continued to work without heating, but with a heavy knock.

At 12.45 a.m. on the 16th, fires were drawn from No. 6 boiler, three new nickel rings inserted, fires lit and boiler again connected at 4.30 a.m. The use of seventeen boilers instead of the full number (eighteen) accounts for the drop in power during the night watches.

Three fusible plugs and one gauge glass were also replaced, as necessary.

At 5.45 a.m. a sudden noise was heard in the port engine room, but for some time no cause could be assigned for it—afterwards it was discovered that both parts of the turning wheel were lying in the bilge, the nuts on the bolts holding the two halves together having apparently slacked back. As this wheel was not required during the trial, no immediate steps were taken to replace it on the shaft.

At 7.50 a.m. on the 16th February, whilst the engines were making 163 revolutions, several loud reports in quick succession were heard in the port engines, and the links were at once centred and the engines stopped. On examination it was found that the port intermediate pressure connecting rod had left the crank, the crank-head bolts having been broken, and the rod had jammed itself between the bedplate and the outside of the astern guides. Steam was shut off the port engines and the starboard engines were used to keep the ship on her course at slow speed.

The turning wheel was then replaced on the shaft, the defective connecting rod removed, valve gear of the port intermediate pressure cylinder disconnected, and the piston and piston valve fixed at the bottom of the stroke, so that the port engine could be worked as a three-cylinder compound instead of a four-cylinder triple-expansion engine. These temporary repairs occupied twenty-seven hours, the time being much extended on account of the necessity of replacing the turning wheel on the shaft.

The accident appears to have been due to the slacking back of the nut on the port bolt of the port intermediate pressure crank-head. This put the whole load on the starboard bolt, which stretched and then broke. The port bolt only now held the cap, and this bolt, after bending, finally broke at a flaw, and allowed the cap and brasses to fall into the crankpit. After this the engines made several revolutions before they could be stopped, and considerable damage was thereby produced, involving the renewal of the cylinder and several working parts.

At 10 a.m. on the 16th, or two hours after the accident, the "Minerva" came up, continued her passage, and when about 70 miles off the English coast forwarded a report by wireless telegraphy of the accident to the "Hyacinth."

The "Hyacinth" made for the nearest home port—Plymouth—at a speed of between fourteen and fifteen knots, and arrived at 2.45 p.m. on the 18th February. During this passage the port turning wheel was again found to be loose on the shaft and had to be removed, for which purpose the port engines were stopped about four hours.

At 5 a.m. on the 18th fires were drawn from No. 14 boiler, two new nickel rings fitted, the fires relit, and the boiler again connected at 8.30 a.m.

The "Minerva" completed her passage off St. Catherine's Point at midnight, and anchored at 1.33 a.m. on the 18th February, the distance of 1,132·5 miles having been steamed in 61½ hours at an average speed of 18·41 knots.

The results of the passage are shown in Tables IV., IVA,, and IVB., the records for the "Minerva" being for the whole period, whilst those for the "Hyacinth" do not extend beyond 7.50 a.m. on the 16th, when the accident occurred. From this table it will be seen that the "Hyacinth" was averaging about half a knot more than the "Minerva." It was reported by the "Minerva" that when passing Tarifa (16¾ miles from Gibraltar) the "Hyacinth" was leading by 35 minutes; further, that in the next 176½ miles she increased this lead to 47½ minutes. At the latter portion of this period of the run the heating of the port engine of the "Hyacinth" occurred, and after passing St. Vincent the engines were eased till the power developed

was 8,900 I.H.P., the "Minerva" then developing 8,460 I.H.P. As a consequence, when passing the Burlings, 148½ miles from St. Vincent, the "Hyacinth" had gained only another 2½ minutes, the "Minerva" reporting her as then being 50 minutes ahead.

After the port engine of the "Hyacinth" broke down the ship proceeded at slow speed. From the time taken by the "Minerva" to overhaul and pass her, it is estimated that at the time of the breakdown the "Hyacinth" was leading by about seventeen miles, of which about nine miles were due to the time gained in getting under way at Gibraltar.

Beyond a few slight leaks in the boilers, probably due to such rapid raising of steam, no trouble was experienced with either the machinery or boilers of the "Minerva."

As regards the boilers of the "Hyacinth," no defects of consequence have been discovered.

No engine defects are reported from the "Minerva."

After the trial the boilers of both vessels were thoroughly examined, and the reports of this examination are appended. (Appendices I. and II.)

The reports of the Chief Inspector of Machinery who attended the trial of the "Hyacinth," and the Inspector of Machinery in the "Minerva," are also attached (Appendices III. and IV.).

W. H. MAY,
Rear-Admiral,
Controller of the Navy.

21st April 1903.

TABLE I.

ENGINE FRICTION TRIALS.

H.M.S. "HYACINTH."

Starboard Engine.		Port Engine.	
Revs.	I.H.P.	Revs.	I.H.P.
178	307·1	180	283·6
164	243·6	161	196·4
143	170·3	140	150·8
121	132·7	123	110·7
102	110·2	102	91·4
80	78·0	82	66·9
60	58·7	60	50·0
40	44·3	39	34·2
20	26·7	24·5	24·8

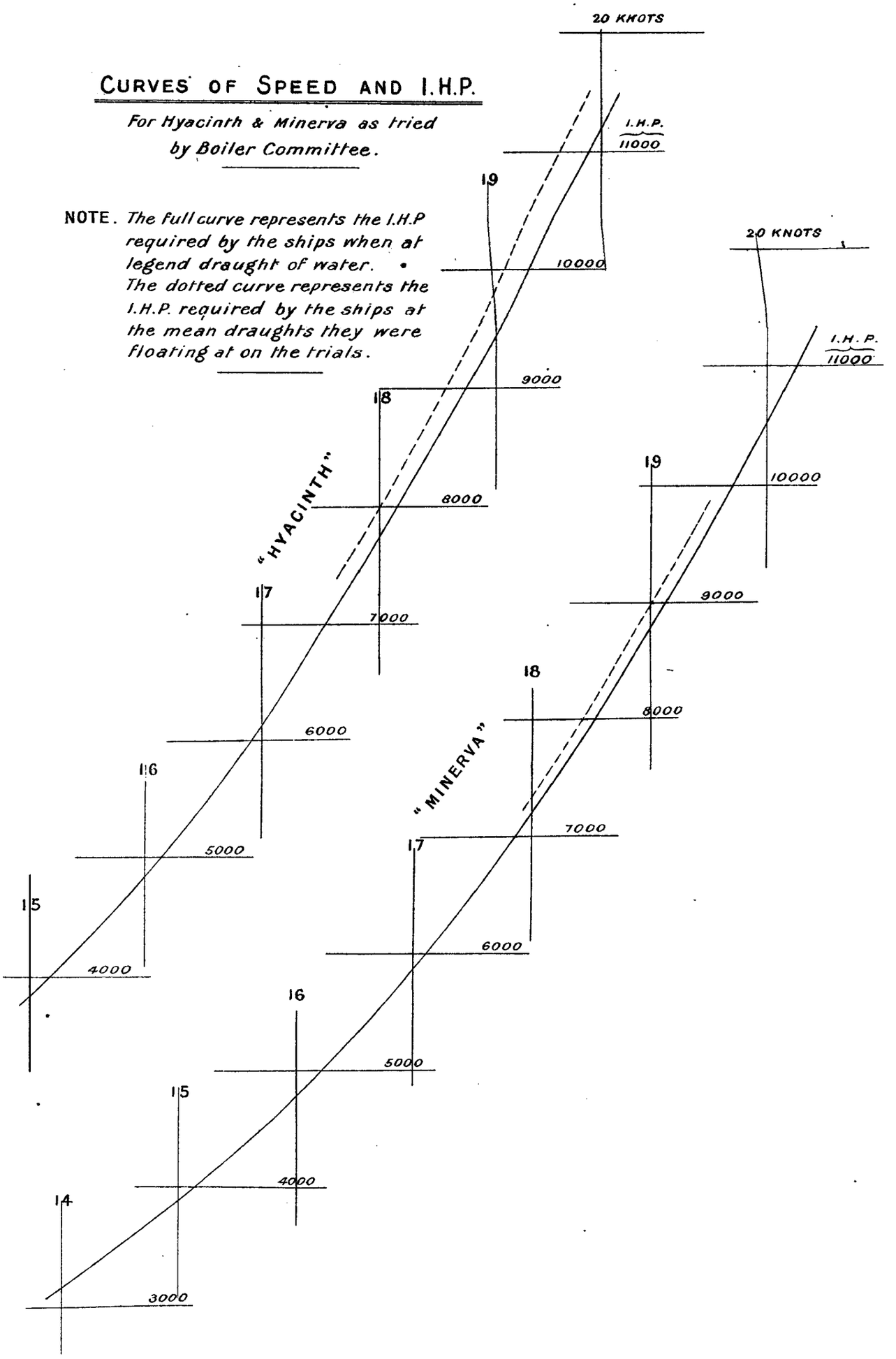
H.M.S. "MINERVA."

Starboard Engine.		Port Engine.	
Revs.	I.H.P.	Revs.	I.H.P.
142	293·3		
140	261·1	143	265·8
122	192·2	119	170·5
101	125·0	102	131·6
82	103·1	80	94·7
62	86·4	62	60·8
41	58·5	39	50·7
19·5	32·1	20	28·8

CURVES OF SPEED AND I.H.P.

For Hyacinth & Minerva as tried by Boiler Committee.

NOTE. *The full curve represents the I.H.P required by the ships when at legend draught of water. The dotted curve represents the I.H.P. required by the ships at the mean draughts they were floating at on the trials.*



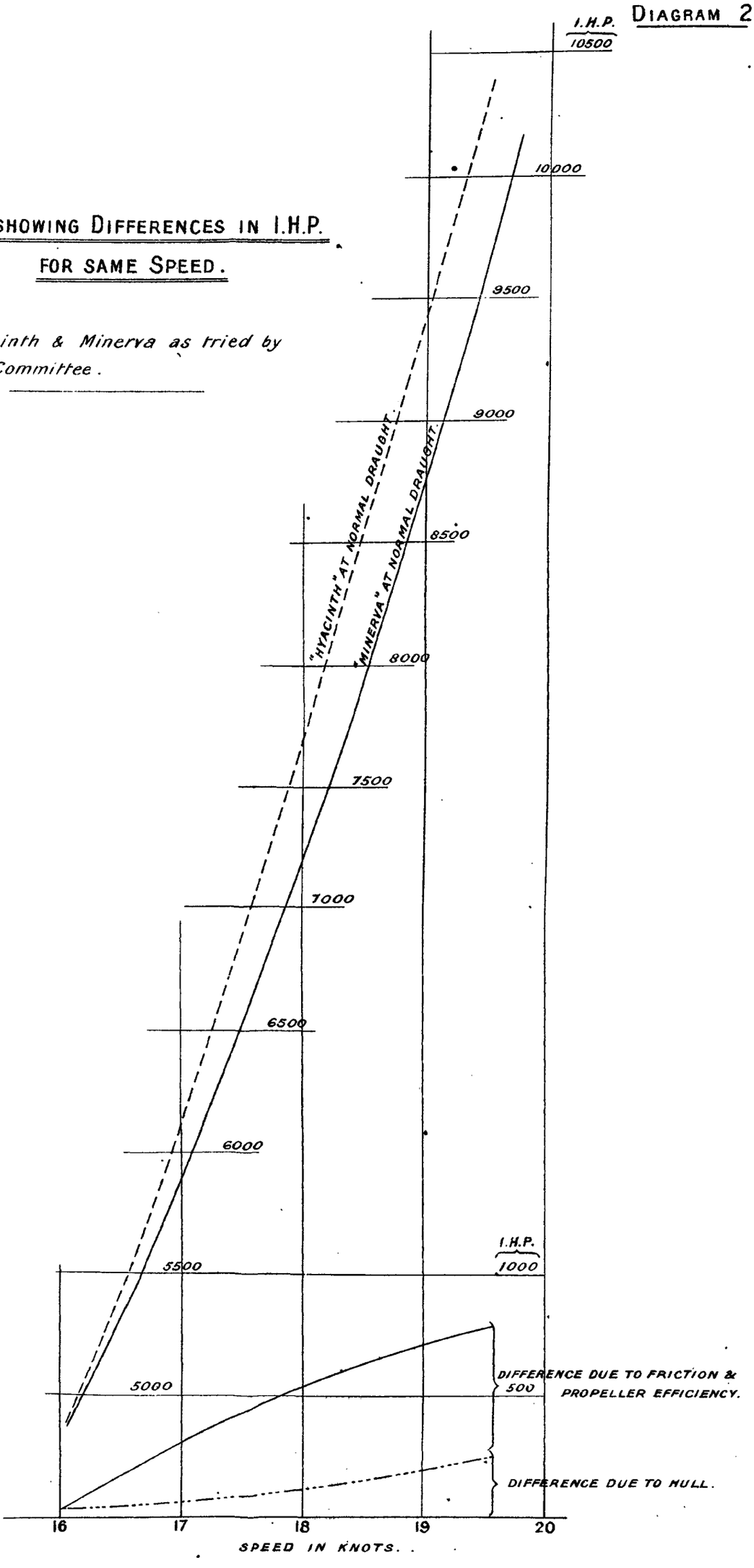
3880. 3:0a.

Weller & Grahams. Ltd Litho London

DIAGRAM 2.

CURVES SHOWING DIFFERENCES IN I.H.P. FOR SAME SPEED.

For Hyacinth & Minerva as tried by Boiler Committee.



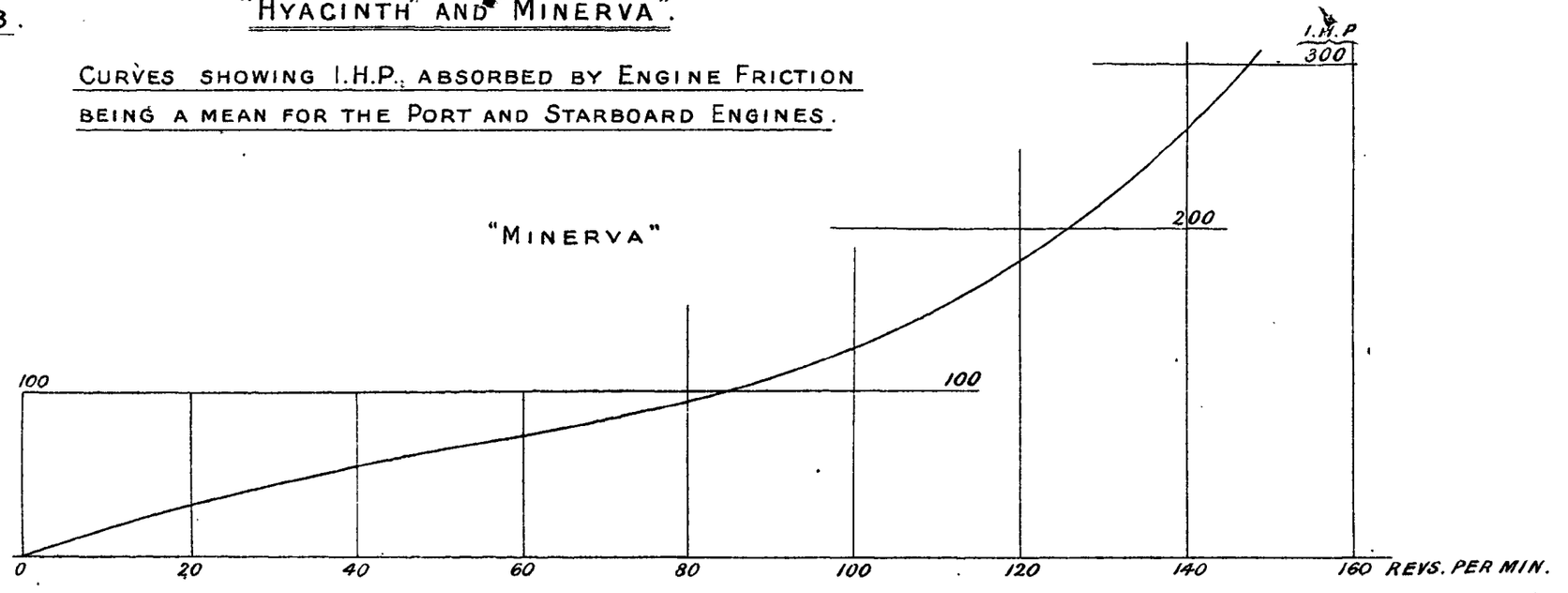
3560.3.03.

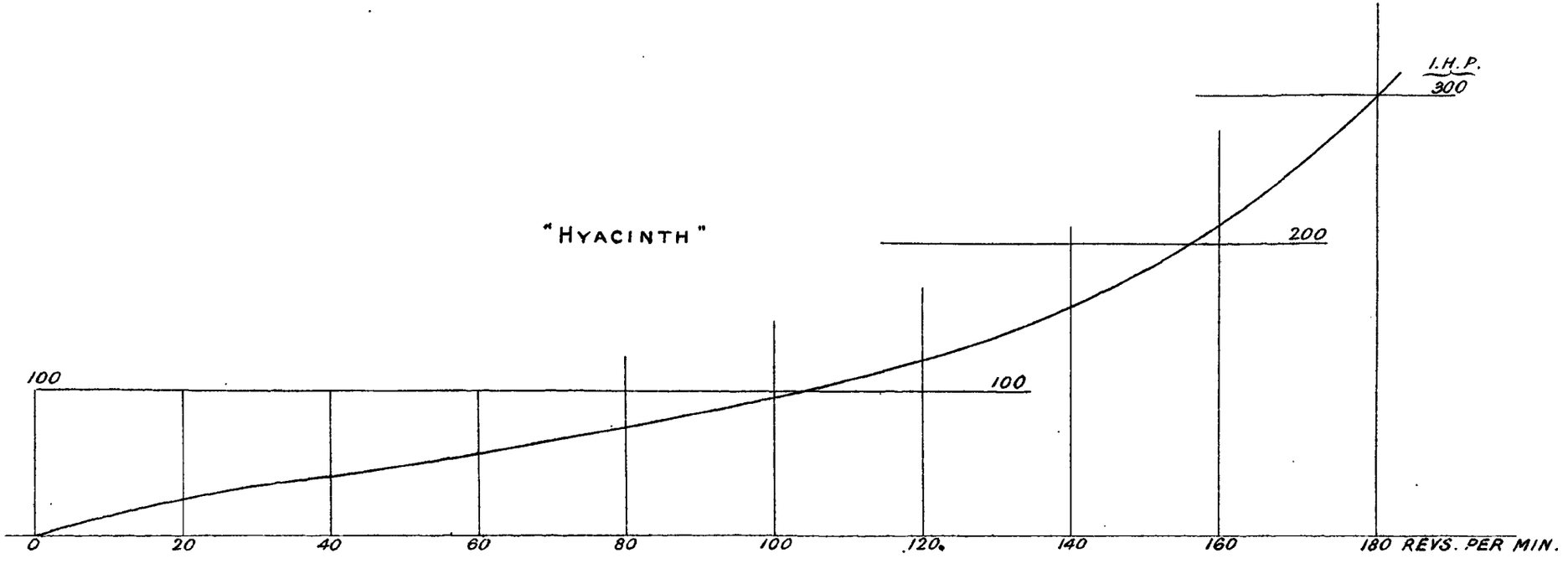
Weller & Grahams, Ltd Litho. London.

DIAGRAM 3.

"HYACINTH" AND "MINERVA".

CURVES SHOWING I.H.P. ABSORBED BY ENGINE FRICTION BEING A MEAN FOR THE PORT AND STARBOARD ENGINES.





Weller & Grahams. Ltd Litho. London.

CURVES OF I.H.P. AND SPEED ALSO OF DIFFERENCE IN I.H.P. FOR SAME SPEED.

"MINERVA" ————————

"HYACINTH" - - - - - - - - - -

FIG. 1.

Hyacinth with propeller A.

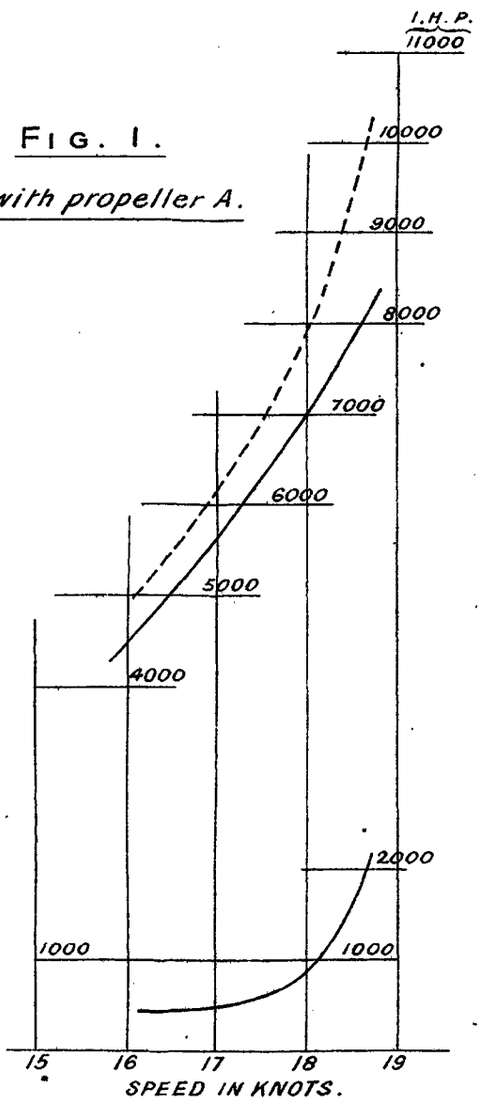
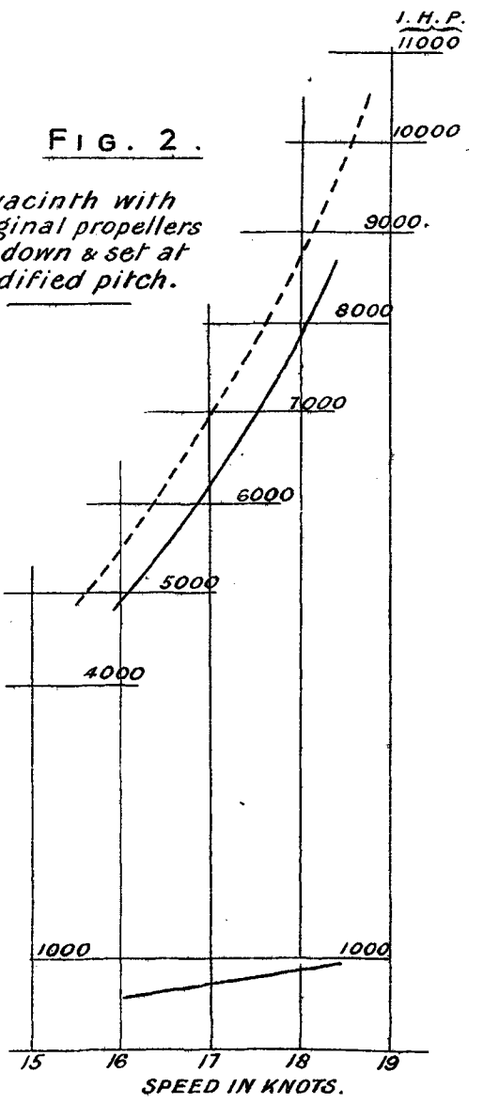


FIG. 2.

Hyacinth with original propellers cut down & set at modified pitch.



3860. 3. 03.

Weller & Grahams, Ltd Litho. London.

CURVES OF I.H.P. AND SPEED, ALSO OF DIFFERENCE IN I.H.P. FOR SAME SPEED.

"MINERVA" ————————

"HYACINTH" — — — — — — — —

FIG. 1.

Hyacinth with propeller B.

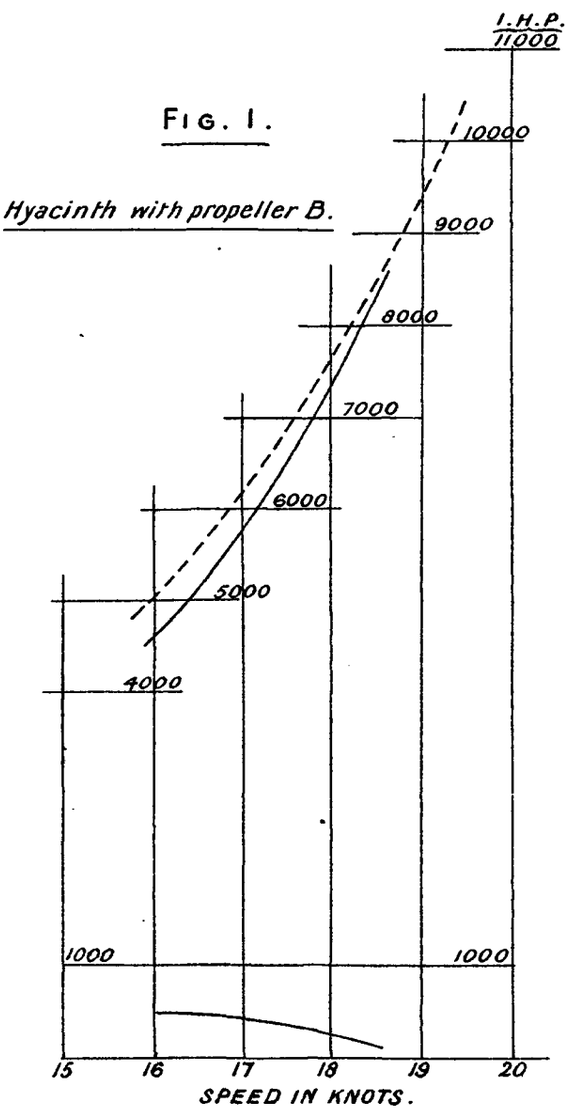
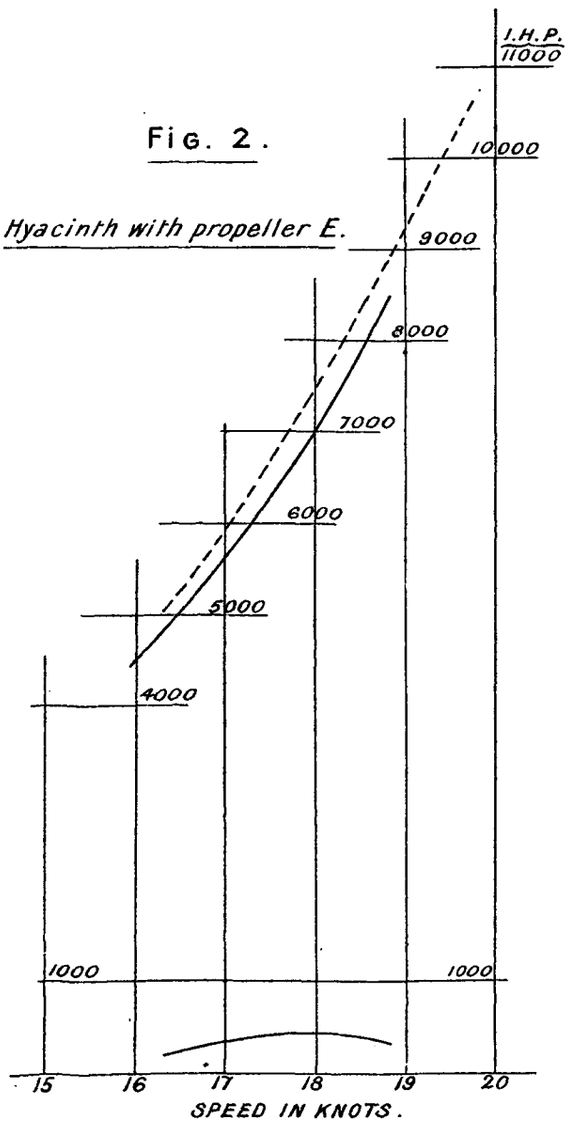


FIG. 2.

Hyacinth with propeller E.



3860.3.03.

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CURVES OF I.H.P. AND SPEED ALSO OF DIFFERENCE IN I.H.P. FOR SAME SPEED.

"MINERVA" _____

"HYACINTH" - - - - - - - - -

FIG. 1.

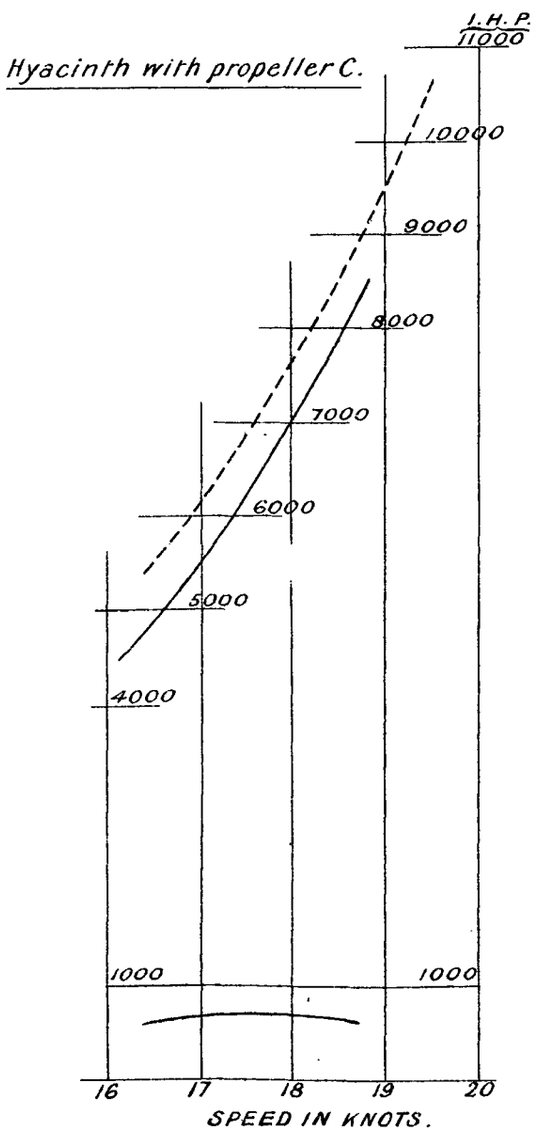
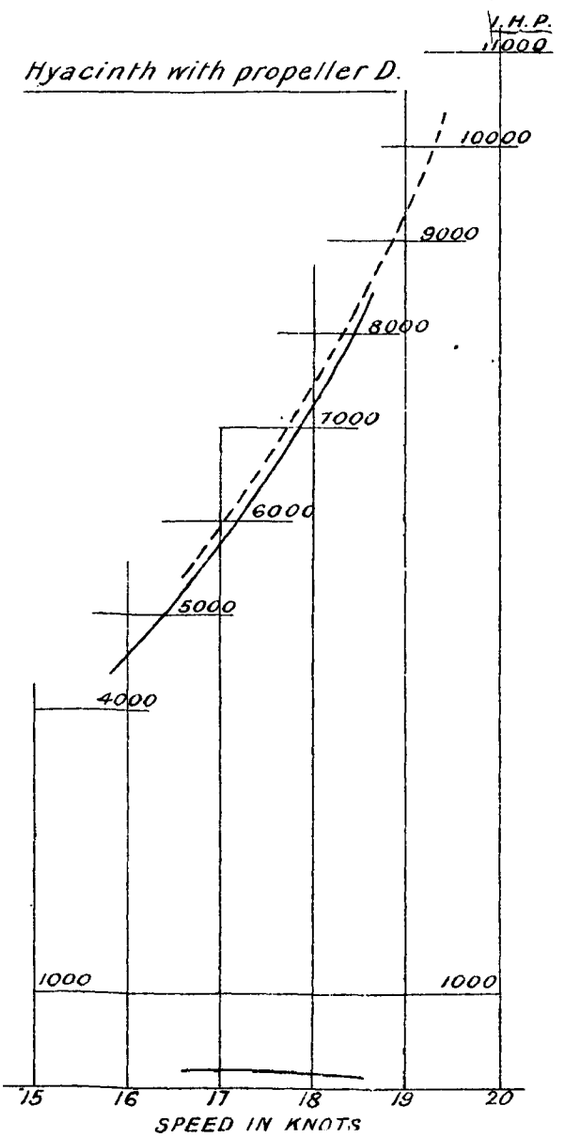


FIG. 2.



3860.3.09.

Weller & Grahams, Ltd Litho. London.

TABLE II.

H.M. SHIPS "HYACINTH" AND "MINERVA."

MEAN RESULTS OF PASSAGE TRIAL FROM PLYMOUTH TO GIBRALTAR, AT 7,000 I.H.P.

—	Duration.	Total Distance Run.	Total Water Lost.	Total Coal Burnt.	Steam Pressure in Boilers.	Revolutions.	I.H.P.	Air Pressure.	Vacuum.	Speed.	Water lost per 1,000 I.H.P. per Day.	Coal per Hour per I.H.P.
	Hours.	Miles.	Tons.	Tons.	Lbs. per sq. in.	Per min.		Inches.	Inches.	Knots.	Tons.	Lbs.
"Hyacinth"	136	2,390 0	169·67	898·5	233·5	152·65	7,014	Nil to 0·2	25·75	17·55	4·28	2·10
"Minerva"	160	2,832·8	183·20	989·0	151·0	122·3	7,030	0·3 to 2·0	25·15	17·72	3·91	1·97

TABLE IIA.

H.M.S. "HYACINTH."

MEAN DAILY RESULTS OF ENDURANCE TRIAL AT 7,000 I.H.P., 4TH TO 10TH FEBRUARY, 1903.

Commenced Trial at 10.30 A.M. 4th February, 1903.

Date and Time.	Duration of Period.	Distance Run.	Water Lost.	Coal Burnt.	Steam Pressure in Boilers.	Revolutions.		I.H.P.			Air Pressure.	Vacuum.	
						Star.	Port.	Star.	Port.	Total.		Star.	Port.
	Hours.	Miles.	Tons.	Tons.	Lbs. per sq. in.	Per min.	Per min.				Inches.	Inches.	Inches.
February 4th and 5th, 10.30 a.m. to 10.30 a.m.	24	419	22·15	142·6	221·0	151·8	150·6	3,418	3,549	6,967	0·03	26·4	26·2
„ 5th and 6th, „ „	24	422	27·02	157·6	242·5	154·4	153·2	3,502	3,613	7,115	0·08	25·4	25·1
„ 6th and 7th, „ „	24	420	32·30	159·9	243 3	154·5	152·9	3,506	3,589	7,095	0·17	26·1	25·5
„ 7th and 8th, „ „	24	427	32·30	159·0	232·5	154·6	152·6	3,515	3,526	7,041	0·18	25·9	25·7
„ 8th and 9th, „ „	24	422	31·90	167·9	230·9	152·7	150·2	3,459	3,458	6,917	0·20	26·1	25·7
„ 9th and 10th, 10.30 a.m. to 2.30 a.m.	16	280	24·00	111·5	230·0	153·0	150·8	3,472	3,453	6,925	0·20	26·0	25·7

TABLE IIB.

H.M.S. "MINERVA."

MEAN DAILY RESULTS OF ENDURANCE TRIAL AT 7,000 I.H.P., 4TH TO 11TH FEBRUARY, 1903.

Commenced Trial at 10.25 A.M., 4th February, 1903.

Date and Time.	Duration of Period.	Distance Run.	Water Lost.	Coal Burnt.	Steam Pressure in Boilers.	Revolutions.		I.H.P.			Air Pressure.	Vacuum.	
						Star.	Port.	Star.	Port.	Total.		Star.	Port.
	Hours.	Miles.	Tons.	Tons.	Lbs. per sq. in.	Per min.	Per min.				Inches.	Inches.	Inches.
10.25 a.m. to 11.0 a.m., 4th February	0·6	8·75	0·47	3·5	153	122·2	122·9	3,519	3,389	6,908	0·30	25·5	25·2
11.0 a.m. to 11.0 a.m., 4th and 5th February	24·0	415·20	24·11	134·0	151	122·1	122·2	3,585	3,475	7,060	0·38	25·2	25·2
„ „ 5th and 6th „	24·0	424·10	29·15	154·0	152	122·7	121·8	3,648	3,388	7,036	0·43	25·3	25·6
„ „ 6th and 7th „	24·0	420·50	30·14	147·0	152	122·5	121·4	3,646	3,379	7,025	0·35	25·0	25·3
„ „ 7th and 8th „	24·0	427·80	27·61	148·0	151	123·5	122·2	3,680	3,330	7,010	0·45	25·1	25·3
„ „ 8th and 9th „	24·0	429·50	27·20	151·0	151	122·8	121·0	3,696	3,338	7,034	0·74	25·0	25·3
„ „ 9th and 10th „	24·0	426·60	28·00	153·0	150	122·9	121·3	3,695	3,318	7,013	1·01	25·0	25·1
11.0 a.m., 10th February, to 2.25 a.m., 11th February	15·4	280·35	16·52	98·5	149	123·7	122·7	3,679	3,353	7,032	1·43	25·0	25·1

TABLE III.

H.M. SHIPS "HYACINTH" AND "MINERVA."

Time taken to Prepare for Sea.

	Time and Date of Arrival.	
	"Hyacinth."	"Minerva."
Completed trial at 7,000 I.H.P.	2.30 a.m. 10.II.1903	2.25 a.m. 11.II.1903
Arrived Gibraltar (New Mole)	8.0 a.m. „	8.0 a.m. „
Completed coaling	2.35 a.m. 11.II.1903	10.0 p.m. 11.II.1903
Left Mole to anchor in Bay	7.30 a.m. „	7.30 a.m. 12.II.1903
Ready for sea as regards defects	11.30 p.m. 10.II.1903	11.20 p.m. 12.II.1903
Left anchorage at Gibraltar	9.26 a.m. 15.II.1903	10.4 a.m. 15.II.1903

	Periods after the termination of Trial at 7,000 I.H.P.			
	"Hyacinth."		"Minerva."	
	Hrs.	Min.	Hrs.	Min.
Completed trial at 7,000 I.H.P.	—	—	—	—
Arrived Gibraltar (New Mole)	5	30	5	35
Completed coaling	24	5	19	35
Left Mole to anchor in Bay	29	0	29	5
Ready for sea as regards defects	21	0	44	55
Left anchorage at Gibraltar—periods after signal to proceed to England was given.	0	26	1	4

TABLE IV.

H.M. SHIPS "HYACINTH" AND "MINERVA."

MEAN RESULTS OF PASSAGE TRIAL FROM GIBRALTAR TO PORTSMOUTH, AT HIGHEST POWER MAINTAINABLE.
("HYACINTH'S" RECORDS TERMINATE AT 8.0 A.M., 16TH FEBRUARY.)

—	Duration.	Total Distance Run.	Total Water Lost.	Total Coal Burnt.	Steam Pressure in Boilers.	Revolutions.	I.H.P.	Air Pressure.	Vacuum.	Speed.	Water Lost per 1,000 I.H.P. per Day.	Coal per Hour per I.H.P.
	Hours.	Miles.	Tons.	Tons.	Lbs. per sq. in.	Per min.		Inches.	Inches.	Knots.	Tons.	Lbs.
"Hyacinth"	21·83	380·7†	32·0*	217·02†	261·0	168·45	9,943	0·4 to 0·8	22·3	19·02	3·51	2·44
"Minerva"	61·5	1,132·5	72·5	476·50	151·5	129·75	8,370	0·85 to 1·5	25·0	18·41	3·38	2·07

* For 22 hours. † For 20 hours.

TABLE IVA.

H.M.S. "HYACINTH."

MEAN FOUR-HOURLY RESULTS OF TRIAL AT MAXIMUM I.H.P., 15TH TO 16TH FEBRUARY, 1903.
Commenced Trial at 10.0 a.m., 15th February, 1903.

Date and Time.	Duration of Period.	Distance Run.	Water Lost.	Coal Burnt.	Steam Pressure in Boilers.	Revolutions.		I.H.P.			Air Pressure.	Vacuum.	
						Star.	Port.	Star.	Port.	Total.		Star.	Port.
	Hours.	Miles.	Tons.	Tons.	Lbs. per sq. in.	Per min.	Per min.				Inches.	Inches.	Inches.
10.0 a.m. to 2.0 p.m., 15th February	4	77·9	4·00	43·26	290	174·9	173·3	5,326	5,272	10,598	0·4	22·0	21·0
2.0 p.m. to 6.0 p.m. „	4	77·6	6·50	45·24	285	173·4	169·8	5,021	5,110	10,131	0·4	22·5	22·0
6.0 p.m. to 10.0 p.m. „	4	77·2	6·95	42·42	260	174·2	168·5	5,416	4,911	10,327	0·8	22·0	22·0
10.0 p.m. to 2.0 a.m., 16th February	4	74·8	5·55	46·26	240	167·9	164·9	4,844	4,877	9,721	0·6	23·0	22·0
2.0 a.m. to 6.0 a.m. „	4	73·2	6·00	39·84	230	164·7	161·9	4,433	4,507	8,940	0·7	24·0	22·5
6.0 a.m. to 7.0 a.m. „	—	18·3	3·00*	—	—	165·3	162·9	—	—	—	—	—	—

NOTE.—The mean results, except where otherwise stated, are calculated on the results for the first 20 hours.
* For two hours.

TABLE IVB.

H.M.S. "MINERVA."

MEAN FOUR-HOURLY RESULTS OF TRIAL AT MAXIMUM I.H.P., 15TH TO 17TH FEBRUARY, 1903.

Commenced Trial at 10.30 a.m., 15th February, 1903.

Date and Time.	Duration of Period.	Distance Run.	Water Lost.	Coal Burnt.	Steam Pressure in Boilers.	Revolutions.		I.H.P.			Air Pressure.	Vacuum.	
						Star.	Port.	Star.	Port.	Total.		Star.	Port.
		Miles.	Tons.	Tons.	Lbs. per sq. in.	Per min.	Per min.				Inches.	Inches.	Inches.
10.30 a.m. to 11 a.m., 15th February	0·5	9·3	0·4	3·9	153	130·7	131·9	4,271	4,331	8,602	1·10	25·00	25·50
11 a.m. to 3 p.m. „	4·0	—	4·8	—	153	131·4	131·8	4,337	4,253	8,590	1·00	25·00	25·25
3 p.m. to 7 p.m. „	4·0	—	4·5	—	153	130·9	131·2	4,263	4,161	8,424	0·85	24·75	25·25
7 p.m. to 11 p.m. „	4·0	—	4·8	—	152	130·7	130·8	4,342	4,162	8,504	0·90	25·00	25·25
11 p.m. to 3 a.m., 16th February	4·0	—	4·5	—	152	130·5	130·6	4,320	4,181	8,501	1·02	25·00	25·00
3 a.m. to 7 a.m. „	4·0	—	4·6	—	151	128·0	128·4	4,208	4,093	8,301	1·38	25·00	25·00
7 a.m. to 11 a.m. „	4·0	24 hours. 443·3	4·5	24 hours. 184·3	152	129·7	130·1	4,285	4,190	8,475	1·26	25·25	25·25
11 a.m. to 3 p.m. „	4·0	—	4·6	—	152	129·2	129·3	4,251	4,094	8,345	1·25	25·00	25·00
3 p.m. to 7 p.m. „	4·0	—	4·8	—	152	129·6	129·5	4,265	4,057	8,322	1·05	25·00	25·00
7 p.m. to 11 p.m. „	4·0	—	4·8	—	151	129·8	129·9	4,294	4,039	8,333	1·05	25·00	25·00
11 p.m. to 3 a.m., 17th February	4·0	—	4·9	—	152	129·7	130·4	4,240	4,142	8,382	1·27	25·00	25·25
3 a.m. to 7 a.m. „	4·0	—	4·7	—	152	128·2	128·6	4,229	4,041	8,270	1·45	25·00	25·00
7 a.m. to 11 a.m. „	4·0	24 hours. 444·8	4·6	24 hours. 185·6	152	129·4	129·9	4,246	4,130	8,376	1·27	25·00	25·00
11 a.m. to 3 p.m. „	4·0	—	5·0	—	150	128·3	128·9	4,204	4,009	8,213	1·32	25·00	25·25
3 p.m. to 7 p.m. „	4·0	—	4·8	—	152	129·4	129·9	4,170	4,103	8,273	1·32	25·00	25·00
7 p.m. to 11 p.m. „	4·0	—	5·0	—	151	129·2	129·5	4,176	4,049	8,225	1·42	25·00	25·00
11 p.m. to 12 midnight „	1·0	13 hours. 235·1	1·2	13 hours. 102·7	150	130·9	130·3	4,255	4,122	8,377	1·40	25·00	25·00

APPENDIX I.

"HYACINTH."

Report of Examination of Boilers after Trial.

Devonport, 26th February.

The boilers of the "Hyacinth" were examined on return from Gibraltar, and found to be generally in good condition.

The feed collectors and tubes were found to be slightly more distorted than when the vessel left, the absolute deflections are shown on sheet enclosed, but there are no prior observations to hand to enable a comparison to be made of the actual increase of deflection during the trip being ascertained.

One downcomer pipe in each of Nos. 16 and 17 boilers leaked very slightly at upper end, and four elbow joints leaked slightly during the passage; six generator doors and eight economiser doors show signs of slight leakage.

Some parts of the boiler casings and fittings were worn before the ship left, but it is not considered that the defects have appreciably increased during this trial.

The brickwork will in places require renewal, and fire-bars, &c., general overhaul, but nothing more than would be expected under similar working.

(Signed) R. H. ANDREWS,
Chief Engineer.

Admiral-Superintendent.

Enclosure to Officer's Letter, 26th February 1903.

Deflections.

No. of Boilers.	Feed Collectors.	Bottom Row of Tubes (Elements).									Remarks.
		1	2	3	4	5	6	7	8	9	
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	
1	$\frac{3}{8}$	$\frac{3}{16}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{16}$	—	
2	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	
3	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	
4	$\frac{5}{16}$	$\frac{1}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{8}$	A few nickels showing signs of leakage.
5	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{1}{4}$	
6	$\frac{7}{16}$	$\frac{1}{8}$	$\frac{5}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{7}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	1 nickel showing signs of leakage.
7	$\frac{1}{4}$	$\frac{1}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{1}{16}$	
8	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{5}{16}$	—	
9	$\frac{1}{4}$	$\frac{1}{16}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{5}{16}$	$\frac{1}{8}$	2 nickels showing signs of leakage.
10	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	—	—	$\frac{3}{8}$	—	—	1 nickel showing signs of leakage.
11	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{8}$	2 nickels showing signs of leakage.
12	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{3}{16}$	2 nickels showing signs of leakage.
13	$\frac{3}{8}$	—	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{16}$	—	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{8}$	—	1 nickel showing signs of leakage.
14	$\frac{3}{8}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{1}{2}$	$\frac{1}{2}$	2 nickels showing signs of leakage.
15	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{3}{8}$	1 nickel showing signs of leakage.
16	Under Steam										
17	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	A few nickels showing signs of leakage.
18	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{3}{8}$	A few nickels showing signs of leakage.

(Signed) R. H. Andrews, Chief Engineer.

Devonport Yard, 26th February, 1903.

APPENDIX II.

H.M.S. "MINERVA.

Examination of Boilers and Machinery after Completion of Full-Speed Run from Gibraltar to Portsmouth.

On arrival at Portsmouth the fires were allowed to gradually die out, and after cooling, the ashes were drawn and each boiler entered for examination on the fire side. The whole of the tube plate was found coated with scoria to an extent varying in thickness from the bottom, and the whole of the tubes were choked about one-half the opening (bottom half). The scoriæ had entered the ferrule to a more or less extent, any accumulation which had been carried past the ferrule was found to have deposited at the inner end of the retarder, this further tending to choke the tube. Apparently very little had been carried past the end of the retarder, and the tubes generally, after withdrawal of retarders and sweeping, were found clean. A great many of the ferrules were found to be loose and were easily dislodged. All projections in the combustion chambers, such as stay nuts, &c., were covered with the same deposit found on tube plate, the general appearance of the whole of the interior of the combustion chamber, including tube plate, showing the effect of blast due to the air pressure, which had carried with it melted particles, and these had gradually accumulated on any projection with which they came in contact. Very slight leaks were discovered in the combustion chambers, as shown in the accompanying list, but none of these would impair the efficiency of the boilers. Some of the unprotected stay nuts at backs of combustion chambers just over bridge had been leaking, as shown by the rust deposit under the scoriæ accumulated, but none were serious. The retarders were slightly burned at ends, but were otherwise in good condition. The deposit of scoriæ on the surface is easily removable, being brittle. The boilers externally were in good condition; one or two slight leaks could be traced at joints in shells, all of which had taken up, but none could be considered of a serious nature. The whole of the boilers were in approximately the same condition. The fire-bars were in good condition, very few requiring renewal; one bearing bar was cracked and was renewed. The brickwork, although in good serviceable condition, had drawn off the plates in places, and at the back of combustion chambers was covered with a coating of slag of some thickness. After cleaning and sweeping, the boilers were ready for further service.

It is considered, however, that from the number of small leaks which had taken place, that rapid steam raising, such as was carried out with this type of boiler, cannot be other than prejudicial to the life of the boiler, and should only be used in cases of exceptional emergency.

The main and auxiliary engines are in good condition, no serious defects being developed; the minor defects can be dealt with by ship's staff.

List of Leaks discovered during Examination.

No. of Boiler.	Starboard Wing Furnance and Combustion Chamber.	Centre Furnace and Combustion Chamber.	Port Wing Furnace and Combustion Chamber.
1	Stay nuts 1 No. had leaked slightly.	Stay nuts 2 No. and slight caulking required for length of 4 inches.	Stay nuts 1 No. had leaked slightly.
	Shell.—Two rivets at bottom of circumferential seam, one rivet at front bottom seam. Starboard centre manhole door had leaked slightly.		
2	Stay nuts 6 No. and 2 rivets on tube plate had leaked slightly.	Stay nuts 4 No., 1 rivet, tube plate, and slight caulking required for length of 4 inches.	Nil.
	Shell.—Butt joint front of boiler, port side. Three rivets at bottom front end. Port breast and centre manhole door had leaked slightly.		

No. of Boiler.	Starboard Wing Furnace and Combustion Chamber.	Centre Furnace and Combustion Chamber.	Port Wing Furnace and Combustion Chamber.
3	4 stays leaked slightly -	11 stays and 2 rivets and caulking had leaked slightly.	Nil.
	Shell.—Slight caulking required for about 6 inches of circumferential seam at bottom. Two rivets at bottom port side had leaked slightly.		
4	13 stay nuts, 1 rivet, and 2 tubes had leaked slightly.*	4 stay nuts and about 6 inches of caulking had leaked slightly.	5 stay nuts had leaked slightly.
	Shell.—Breast doors had leaked slightly.		
5	1 stay nut had leaked slightly.	12 stay nuts and slight leak had taken place along 6 inches of caulking.	5 stay nuts had leaked slightly.
	Shell.—Breast doors, auxiliary feed joint, and about 2 inches of caulking had leaked slightly.		
6	3 stay nuts - -	2 stay nuts and about 6 inches of caulking had leaked slightly.	Nil.
	Shell.—1 stay nut and 1 rivet back of boiler had leaked slightly.		
7	1 stay nut - -	4 stay nuts and 2 rivets.	4 stay nuts.
	Shell.—Circumferential seam at bottom had leaked slightly for about a length of 6 inches. Butt joint on shell, slight, and auxiliary feed valve joint.		
8	2 stay nuts - -	5 stay nuts, 2 rivets, and about 4 inches of caulking.	Nil.
	Shell.—2 rivets at back of boiler, main feed valve joint, butt joint front of boiler had leaked slightly.		

* One ferrule had dropped out and another partly out.

(Signed) P. C. W. HOWE,
Assistant to Chief Engineer.

(Signed) J. B. BARRABLE,
Foreman of Boilermakers.

APPENDIX III.

REPORT OF LONG-DISTANCE TRIALS OF H.M.S. "HYACINTH."

H.M. Dockyard Reserve, Portsmouth,
26th February 1903.

SIR,

I BEG to forward for the information of their Lordships the following report on the long-distance trials of H.M.S. "Hyacinth" between the 4th and 18th February 1903.

Leaving Plymouth Sound at 9.45 a.m. Wednesday, the 4th February, "the coal-endurance trial" at 7,000 I.H.P. was commenced at 10.30 a.m., and this was continued until the coal was expended to the limit ordered by their Lordships in the Admiralty Letter dated 26th December 1902. This trial was completed at 2.30 a.m., Tuesday, the 10th February, during which time the ship had run a distance of 2,390 miles in 136 hours at a mean speed of 17·6 knots, using 898·5 tons of coal and burning 19·7 lbs. per square foot of grate surface, with a mean I.H.P. of 7,014, a coal consumption for all purposes of 2·1 lbs. per I.H.P., and a water loss of 170 tons, or 4·2 tons per 1,000 I.H.P. per 24 hours.

On proceeding into Gibraltar, on Thursday, 10th February, the defects (which were made good by ship's staff) were as follows:—

Starboard high pressure crank-head to adjust.
One port main bearing to adjust.
Port surface condenser to test.
Port Weir's evaporator to change coil.
"Outside" glands of piston and slide rods to re-pack.
Both reducing valves spindles to re-pack.
Joints of 10 doors on economiser tubes to re-make.
A few other joints of minor importance to re-make.

These were reported as being completed in 13·50/60* hours, or 3·10/60 hours before the ship was coaled.

Steaming to the anchorage at Gibraltar, on the 11th February, after taking in coal and water, the water was changed in all boilers and their Lordships' orders complied with in this respect at 1.30 p.m., viz., to have water not more than 85° F. in all boilers; this was therefore accomplished, and the ship reported ready to proceed in 29½ hours, this being the number of hours since commencement of making good defects.

On Sunday, 18th February, steam was ordered by signal to be raised "with all despatch," and in 25 minutes the engines moved "slow ahead"; in 50 minutes the ship was steaming 18 knots and "the full speed trial" commenced 1 hour after lighting fires.

After 6 hours at full speed, the port intermediate crank-head brasses became heated, but not to such an extent as to cause the engines to be eased; after this bearing had been cooled with water, a knock was noticed, but not so heavy as to render its being necessary to refit the bearing.

During the night of Sunday this bearing remained in the same condition, but at 7.50 a.m. on Monday the bolts of the connecting rod brasses broke, and after several heavy blows the engines were stopped, when it was found that the brasses and bolts of this bearing were broken, the astern guides cracked, and several lubricators and pipes smashed. It was then decided to compound the port engines, and this was accomplished after 27 hours' continuous work, the ship then proceeding at 14½ knots to Plymouth, the engines working well up to 15 knots, and using 12 boilers during the first part of the time and finishing with 15 boilers.

During the 22 hours the engines were working at full speed, a mean I.H.P. of 9,942 was developed with a speed of 19·6 knots, and with the exception of the heated crank-head, the machinery worked well.

Owing to the high rate of speed, the slackness of the bearing was not fully realised, but had it been necessary to ease the engines, I am of opinion it would have been clearly known.

At the time of the accident, the Chief Engineer of the ship was close to the bearing, the Senior Engineer in the stoke-hold, and the Junior Engineer (Mr. Hobbs) was the Engineer of the watch. Mr. Hobbs very promptly reversed the engines, and by so doing, in all probability averted what might have been a terrible disaster.

I beg to make the following remarks upon the working of the Belleville boilers; the intention of the trials being to prove the efficiency, or otherwise, of these boilers:—

1. The coal endurance trial proved that the radius of action of this ship was governed entirely by the coal on board, for steam was kept quite as easily at the conclusion of 136 hours as at the commencement of the trial, also "the loss of water" never exceeded 32 tons per 24 hours, this loss being easily supplied by two out of the four distillers fitted on board, and working quite easily.
2. The defects in the boilers were quickly made good after the six days' continuous steaming, the delay at Gibraltar being governed by the time required to coal and water the ship.
3. Steam was rapidly raised and engines moving in 25 minutes, and the ship making 18 knots, as previously stated, in less than one hour from the time of lighting fires.

* This period measured from arrival of ship at Gibraltar.

4. The feed arrangements worked most satisfactorily during the whole time. The boilers were fed entirely by the automatic arrangements, great attention being always given to these fittings: 1st, to the packing of the spindle glands, and 2nd, to their being kept clean from coal dust, &c., by regular wiping. The water gauge indications were always quite reliable.
5. The reducing valves were worked continuously with a difference of 40 lbs. between engines and boilers, and any reduction or increase of revolutions of engines regulated by them, so that neither the links nor throttle valves were altered during the whole trial.
6. The air-blowing engines (with a pressure of 11 lbs. kept) were continuously used, and with very satisfactory results, continued observation showing very moderate emission of smoke and no flaming at the funnels.
7. There was no tendency to priming at any time, and the steam was quite dry, there being no indication of water in the separators.
8. During the six days' trial, nine fusible plugs were replaced, eight new gauge glasses and two new nickel rings fitted.
   These items occurred on different occasions, and no difficulty was experienced in dealing with them.
9. Lime was used continuously from 1 lb. to 2 lbs. per ton of water in each boiler; there was no difficulty in using this quantity, and the water in the boilers was always "alkaline."
10. The fan engines for forced draught were used continuously, a mean air pressure of 0·2 ins. being kept, so as not to force the fires, and to keep them in the same condition as far as possible.
11. The closed exhaust system was tried for eight hours, but with two Weir's evaporators working at 25 lbs. pressure, they would not supply enough for "make up"; this was in consequence discontinued after that period.
12. All the ordinary auxiliary work of the ship was carried out during the trial as usual, such as refrigerating machinery, engines for flushing and washing purposes, &c., but no distilling was done for the ship's use.
13. An average of 22 seamen per day were lent for coal trimming, it being difficult to trim from the upper bunkers, when coal was away from water-tight doors.
14. The coal used was ordinary Welsh, and with quality Nos. of 6 to 7, it was of fair size, very dusty and quickly clinkered.

I regret very much to have to report the breakdown of the port intermediate engine after 22 hours' steaming, which causes my remarks to be almost entirely confined to the 7,000 I.H.P. trial; but during the time of the higher power, viz., a mean of 9,942 I.H.P., the boilers worked quite satisfactorily.

No measured record of "loss of water" can be given for this period, as the procedure determined upon was to keep the reserve tanks "full," using two Weir's evaporators for the first 24 hours, and then when fires were getting dirty, and other things, probably, making it somewhat more difficult to keep steam, to stop the evaporators, and use from "the known quantities" in reserve tanks; but from the knowledge of the output of the two evaporators which were used it was approximated that the "loss" was certainly not more than 40 tons per day, or four tons per 1,000 I.H.P. per 24 hours.

All other working parts reported upon for the 136 hours' trial acted similiarly and satisfactorily for the 22 hours' trial, and there is no reason to doubt that the boilers would have worked efficiently for the passage to England, and developed a mean I.H.P. of quite 9,500.

I have, &c.
(Signed) JOHN PITT,
Chief Inspector of Machinery.

APPENDIX IV.

Report on Long-Distance Steam Trials of H.M.S. "Minerva" to Gibraltar and Back, 4th to 18th February 1903.

The coaling was satisfactorily carried out at Devonport in compliance with instructions contained in Admiralty Letter S.29259, dated 26th December 1902. By estimate of remains, and carefully weighing the coal received from s.s. "Greenhill" in bags, it was found that the main bunkers held 1,039 tons, and the reserves 88 tons. The bunkers were closely stowed, but all pockets and coal shoots were empty. Owing to unsatisfactory working of the port high-pressure engine on the passage from Portsmouth on the 29th January, the piston and rod were landed for careful overhaul and adjustment. A preliminary short run was not satisfactorily obtained until the morning of the 4th of February. Additional coal had been stowed on deck, but the bunkers could not be kept closed longer than 2.30 a.m. on the 4th, between which time and the commencement of the trial at 10.25 a.m., 16 tons had been used. It was considered that a satisfactory compliance with the instructions would be given by continuing the trial until 34 tons remained instead of 50; about 2 tons were expended in culinary purposes. The actual remains at the end of the trial were 32 tons, making a total consumption for the trial of 989 tons. The 88 tons in the reserve bunkers remained untouched. The expenditure during the trial was measured by counting the number of skids used each hour, and correcting the weight by survey of remains at Gibraltar. After the first 12 hours each fire was separately cleaned out and re-lit every succeeding 12 hours, by clearing eight fires per four hours watch.

At 9.42 a.m. on the 4th February, on starting from the anchorage in Plymouth Sound, the engines began working up, till at 10.25 the 7,000 I.H.P. was obtained and the trial commenced. The engines, boilers and auxiliary machinery worked satisfactorily with a few unimportant exceptions throughout. The trials lasted 160 hours and the horse power was steadily maintained. The high-pressure piston and slide rod gland blew badly after the second day, and, with the addition of a few small leaks, resulted in a higher water loss than noted on the previous trial.

Before leaving Plymouth the eight double bottom compartments used as reserve feed tanks were filled, and contained nearly 170 tons. The two compartments abaft the original reserve feed tanks, holding 34 tons, were closed, so that any error in estimating the final 6 tons in the other six compartments would be small. At 10.25 on commencing the outward run the reserve feed tanks were estimated to contain 168·6 tons. At 12.40 p.m. on the 8th, after 98¼ hours, the six tanks in use held 12 tons, of which 6 tons were not available on account of the height of connecting holes above the the floor. This with the 34 tons remaining untouched in the after tanks was therefore taken as the reserve of 40 tons ordered, and the evaporators were kept in use with short interruptions till the end of the trial.

Gibraltar was passed at 11 p.m. on the 6th, and the trial continued by runs between that place and Cape de Gata until 2.25 a.m., completing 160 hours.

In order to prevent any communication with the reserve feed tanks from the delivery of the 4½-in. Downton pump used for distributing the ship's drinking water, a length of the branch to the reserve feed tank was kept removed and under observation during the outward and homeward trials.

Thirty-nine deck hands, 13 in each watch, were employed in coal trimming during the outward run.

The emission of smoke observed from the "Hyacinth" during the run was unusually light, and generally did not exceed that of the "Minerva."

On the completion of the trial the ship was anchored at 3.40 a.m. Fires of Nos. 8, 6, 5, 7, and 2 boilers were drawn, and ashes sent up before going alongside the Mole. This was done to avoid handling the ashes from the ship across the Mole, which would have interfered with coaling and obstructed the stokehold space required for the removal of the retarders.

No. 8 boiler having been prepared for harbour use, was connected up at 1 a.m. on the 12th, and steam raised in Nos. 6 and 7 boilers in time to return to the anchorage after coaling.

The clearing of the ferrules was commenced at 4.30 a.m. on the 11th by passing augurs through from the front ends, the dampers being shut and the retarders removed.

In five to six hours after fires were drawn, men were working in two short spells, knocking off the scoria and cleaning inside the combustion chambers.

The retarders were found very little affected, the greatest reduction in length being about $1\frac{1}{2}$ ins., the slight accumulation of scoria being easily removed. The tubes were swept, but no scraping was required. The brick arch at the throat seams were down in three furnaces, a few slight leaks were lightly caulked in combustion chambers, but no leaks were found in the shell. A few fire bars only required renewal.

The preparation of the boilers proceeded as fast as possible, and was completed by 11.10 p.m. on the 12th.

Towards the end of the trial a heavy accumulation of scoria could be seen hanging from the throats of the furnaces. Inside the combustion chambers it was afterwards apparent that a heavy deposit on the lower part of the tube plate had been partly removed by the augurs, and that it extended in diminishing thickness to the top; several ferrules had been dislodged by the augurs; some of these were found to be completely choked, and in others about three-quarters of the opening was closed. The scoria extended nearly to the end of the ferrules, but not into the tubes.

The air pressure towards the end of the trial frequently reached a maximum of 2 ins., in order to maintain the power. It was considered that a further increase of air pressure was not only inadmissible, but that a rapidly increasing rate of choking would result. From the extent to which the choking was actually observed, it is very doubtful whether the 7,000 I.H.P. could have been maintained while the 32 tons remaining in the bunkers lasted.

The "Hyacinth" having completed to 1,012 tons of coal, taking a probable difference in consumption on the homeward run of 70 tons, and allowing for harbour use and for steaming to the anchorage from the Mole, it was decided to complete to 976 tons, in order that the mean weight of coal carried on the homeward run should be about equal in each ship. The amount taken by the "Minerva" was 860 tons between 9.45 a.m. and 9.30 p.m. It was carefully weighed and the quantity confirmed by the survey of the bunkers. It should be observed that the rate of coaling depended on the local arrangements, and was not limited by the rate of stowage in the bunkers. The amount of coal in bunkers at 10.30 a.m. was 950 tons.

Before reporting the boilers ready, combustion chambers and all ferrules and retarders had been cleaned and replaced, the brickwork generally repaired, and the fire bars renewed as necessary, and no further preparation work was done.

The fires were laid the next day while the boilers were cooling.

The main engines required a few adjustments, all the high-pressure piston and slide rod glands were repacked and the metallic packing refitted, and several broken springs renewed. This failure of the springs was undoubtedly the cause of the leaking at the glands during the run. The pistons and cylinders were examined by removing the bonnets, and the port high-pressure cover removed for examining the piston. The starboard intermediate pressure crosshead was adjusted and a main bearing opened out. Three small pipes were rebrazed by the Dockyard and replaced while alongside. The engines were reported ready by 10.30 p.m. on the 12th, and no further work was done.

Gibraltar.—Raising Steam and Warming Engines, Sunday, 15th February.

The method of rapidly raising steam by lighting fires in all furnaces at once, as adopted on previous similar trials, when the water in the lower part of the boilers was already hot, was considered inadmissible under the conditions ordered, with cold water throughout.

Having regard to their previous performances, the arrangement of the furnaces and combustion chambers, the absence of leaks and their thorough cleanliness, the boilers of the "Minerva" were considered to be in a condition exceptionally capable of withstanding the severe strain of rapid steam raising. In order to reduce the risk of causing serious leaks likely to appreciably lower the results on the full-speed run, and at the same time to raise steam with as much rapidity as would be ventured in an emergency, the water in all the boilers was reduced to about $\frac{3}{4}$ in. in the gauge glasses, first one wing-furnace and then the centre furnace in each boiler were lit, the wing-furnace being urged in advance of the centre one. By this means it was expected a more rapid circulation would be set up, thus displacing the cold water below the furnaces, and that steam would be raised in from 2 to $2\frac{1}{2}$ hours. Shortly before lighting up, the temperature of No. 6 boiler varied from 131° F. at the water gauge to 99° at the hydrometer cock, due to the radiation from No. 8 in use for auxiliary purposes.

The average temperatures of the other six boilers were 84·6° F. at the water gauges and 76° at the hydrometer cocks.

The wing fires were lit at 9 a.m. and the centre fires a few minutes after, the fans working slowly on open stokeholds. Steam was first shown in No. 6 at 9.30, and by 9.50 reached 75 lbs. At 9.56 it was connected up with 108 lbs.

In the other boilers, in about 35 to 45 minutes the water below the unlit furnaces was felt to be hot, and the third furnaces were then lit up. Steam began to show at the air cocks in about 45 to 50 minutes from lighting up. They were connected up as follows: Nos. 5 and 7 at 10.8. a.m., Nos. 3 and 4 at 10.10., and Nos. 1 and 2 at 10.12 a.m. At 10.15, or $1\frac{1}{4}$ hours after lighting up, all boilers showed about 150 lbs. pressure. The stokeholds were closed at 10 a.m. On examining the accessible parts of the boilers, leaks were noted at the butt-straps at junction of circumferential plates in fronts of Nos. 1, 2 and 7, stud of smoke-box on No. 1 boiler, and two breast doors in all boilers except No. 8.

The main engines and steam pipes were cold, the temperature over the high-pressure and intermediate-pressure cylinders being 78° to 80°. At 9 a.m. steam was admitted to the cylinder and slide jackets by a small opening of stop valve on No. 8, the jacket supply, and the regulating valves—all drains being open. At 9.20 the low-pressure cylinder was cold at the top and scarcely warm to the touch at the bottom, the high-pressure being fairly warm. The low-pressure cylinder cover did not feel hot to the hand till 9.50. At 9.55 the links were worked ahead and astern slowly, and the warming proceeded more rapidly. At 10 a.m. both low-pressure cylinders were sufficiently warm to move, and at 10.3 proceeded slow ahead with Nos. 6 and 8 boilers only. By 10.12 all boilers were connected, and at 10.15 the revolutions were 120 port and 126 starboard, and at 10.20 130 revolutions and an I.H.P. of 8,321 was measured by diagrams.

In starting the engines there were no indications of water in the cylinders.

The two forward compartments of the double-bottom reserve feed tanks were closed and kept empty for the homeward run. Before raising steam on the 15th, the reserve feed tanks were estimated to contain 137 tons; by 10.30, all boilers being at half glass, the reserve of feed water was 128 tons.

The main engines worked satisfactorily, the high-pressure glands of piston and slide rods remaining practically tight throughout the trial. The greatest amount of feed water make-up during four hours was at the rate of 30 tons per day, and the average 28·3.

The auxiliary engines worked satisfactorily.

The boilers also worked satisfactorily, and the power was well maintained; the air pressure reached a maximum of 1·5 inches.

The joints of two auxiliary feed valves (8 and 5) and main feed valve (No. 7) to front of boiler, and the cover of running down valve of No. 4, developed leaks after running about nine hours.

The engine trial lasted $61\frac{1}{2}$ hours and was ended off St. Catherine's Point at midnight, and the vessel anchored at 1.33 a.m. on the 18th.

The total coal consumed from 10.30 a.m. on the 15th to midnight on the 17th, the end of the trial, was 476·5 tons, estimated by skids used, and corrected by survey of remains in bunkers by the reserve officers from Portsmouth.

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The water remaining in the feed tanks was 80 tons, the amount used in addition to that evaporated being 48 tons.

A general examination of five of the boilers was made by the ship's artificers as soon as the combustion chamber could be entered. In view of the later thorough examination by the Dockyard, precise particulars were not noted. The ferrules generally were partially choked by scoriæ, the deposit being heaviest at the lower rows, the least opening being only sufficient to admit two fingers. No attempt was made to clear them under way on account of the certainty of a portion becoming dislodged and the tube ends becoming overheated. One ferrule was found to have worked out during the trial, and it is important to observe in this connection that the junction of tube and tube-plate was found to be leaking. Several leaks were reported at stay ends, some rivets and parts of seams of the combustion chambers. The considerable portion of the shell covered by lagging could not be examined.

As a general conclusion it is considered the several leaks noted are due to the straining inseparable from the rapidity with which steam was raised; and although the information derived from the trial, as to the possibilities of quick steam raising under the pressure of urgency, is most valuable, having regard to the continued efficient life and cost of repairs in boilers of this type, it is also strong evidence in support of the soundness of the general practice of slow steam raising enjoined by the Regulations.

With reference to the choking of the ferrules, the extent and rapidity of this action would appear to depend largely upon the quality of the coal used, as to the proportion of scoriæ-forming constituents. The result may also possibly be affected to some extent by similar constituents in the material of the firebrick lining used. The subject might well repay investigation by metallurgical chemist experts.

For clearing the ferrules before serious choking occurs, a tool made on the idea suggested in sketch* might be found useful in lessening the risk of displacing the ferrule.

The untiring endeavour on the part of the Officers and men to ensure the best results for the "Minerva" was most excellent and remarkable throughout the trials.

(Signed) E. Little,
Inspector of Machinery, R.N.

19th February 1903.

Sketch not reproduced.